

Discussion of Cold Electronics Development for DUNE/SBND

AUGUST 20TH, 2015

Outline

- Continued Support for Cold Electronics Development
- Accelerated Cold Electronics Development
- SBND Cost Estimate
- DUNE Cost Estimate
- Summary

Continued Support for Cold Electronics Development

- *Continued (expanded) support for cold electronics development, together with TPC integration, is crucial*
 - Cold electronics development (both ASIC design and evaluation test) requires continued support to make steady advancement for various neutrino experiments with final goal to instrument DUNE 10kt
 - To ensure the EE (electrical engineer) readily available when design revision is required
 - Stop-and-go development (supporting development only periodically) is not efficient in a project of this magnitude and in advanced technology
 - MicroBooNE would not be instrumented with FE ASICs without strong support of LBNE LArTPC program
 - Continued support is important for the long term goal of DUNE 10kton installation by ~2020, including various intermediate steps
 - SBND
 - protoDUNE at CERN
 - Vertical slice & production test stands
 - What is shown next is the *minimum* resources required to maintain the cold electronics development efforts

Continued Support for Cold Electronics Development

- 1.5 FTE EE/ET per year for cold electronics development in Instrumentation is a reasonable estimate
 - 0.5 FTE EE for ASIC development
 - For limited modifications (FE ASIC with built in pulser, ADC ASIC with improved DNL)
 - 1 FTE EE/ET for cold electronics boards and ASIC test boards development
 - *EE should have deep understanding of ASIC evaluation test, such as J. Fried*
 - This is a great leverage of Instrumentation resources that BNL has invested in the cold electronics development since 2008
 - ~\$350k labor per year

Continued Support for Cold Electronics Development

- Additional (*minimum*) effort will be required for system integration test and QA/QC in Physics
 - 2.5 FTE EE/PD are required for DUNE and SBND cold electronics development
 - 0.5 FTE EE + 1 FTE EE PD will focus on system integration
 - 1 FTE PD will focus on the evaluation test
 - \$280k ~ \$400k labor per year
 - 1 PD may be covered by base program
 - More scientific effort (BNL, FNAL and collaboration institutes, without project support)

Continued Support for Cold Electronics Development

- M&S for prototype submission of two ASICs
 - Fully burdened cost is ~120k with 19% overhead for each submission
 - \$60k for FE ASIC submission will yield 40 chips, additional 40 chips can be obtained at a cost of \$2k
 - Similarly, \$60k for ADC ASIC submission will yield 40 chips, additional 40 chips can be obtained at a cost of \$2k
 - ~\$240k for two prototype submissions for each ASIC to implement and verify design advancements

Accelerated Cold Electronics Development

- It has been discussed recently to accelerate the cold ASICs development, to meet the requirements of both SBND and protoDUNE at CERN
 - Plan to submit the first prototype of FE and ADC ASICs in January 2016
 - Second submission is planned in July/August 2016 after the full evaluation of the first submission
 - Prototype ASICs will be compatible with both FPGA and COLDATA, based on the discussion in July
 - New features will be considered, with careful examination of schedule impact
 - Finalize the list of modifications by early November

Accelerated Cold Electronics Development

- To accelerate the cold ASICs development, more efforts will be needed
 - Two EE graduate students for ASIC design will start in August/September for two years
 - *0.5 FTE EE for ASIC development to account for increased scope of ASIC revision and supervision of students*
 - \$50k each student per year, \$100k per year
 - License of ASIC development tools, \$100k per year
 - One license seat shared by two students
 - Students will contribute to ASIC design, simulation, documentation, evaluation test and get it ready for production submission for SBND and protoDUNE in 2017
 - In summary: ~\$200k in addition per year to accelerate the ASIC developments, or ~\$400k for two submissions in two years

SBND Cost Estimate

- SBND budget covers one prototype submission for each ASIC
 1. 0.5 FTE ASIC design EE for revision of two ASICs for limited scope of modifications
 2. ~\$120k for one prototype submission for each ASIC
 3. 1.5 FTE EE/ET for cold electronics boards and ASIC test boards development, system integration test and QA/QC
- The SBND fund arrived at BNL only covers item 3) cold electronics boards and ASIC test boards development
 - It is ~\$350k
 - It may be re-purposed to cover item 1) and 2) the ASIC development and submission if approved

DUNE Cost Estimate

- There is ~\$150k planned for FY16 cold electronics development in the current schedule
- There is ~\$640k planned for FY16 protoDUNE cold electronics production
- If protoDUNE production fund can be re-purposed, there will be ~\$790k available for cold electronics development in FY16
 - Can not all be re-directed, as it will impact other developments (cold cable, feed-through etc.)

FE/ADC Chip Production Plan in FY17

- SBND and protoDUNE will need ~2,000 FE ASICs and ~2,000 ADC ASICs
 - 704 for SBND + 960 for protoDUNE + 20% spares
- Two options (no overhead is included)
 - Option 1: MPW run with additional wafers
 - ~\$150k for FE ASIC and ~\$150k for ADC ASIC, total ~\$300k
 - ~\$50k for MPW run, 50 additional wafers (40 chips per wafer) @ ~\$2k each
 - Option 2: Dedicated run with additional wafers
 - ~\$250k for both FE and ADC ASICs
 - One mask for both FE and ADC ASICs
 - ~\$200k for mask of dedicated run, 25 additional wafers (180 FE + 180 ADC chips per wafer) @ \$2k each
 - Will get ~5,000 chips for each ASIC

Cost Estimate

- *We will need to verify if combined SBND/DUNE budget can cover*
 - Two prototype submissions of each ASIC
 - Both labor and M&S
 - Cold electronics boards development, system integration test and QA/QC of SBND and protoDUNE at CERN
 - Both labor and M&S
 - Additional efforts to accelerate the development
 - ~\$200k per year for 2 years
- More details of the cost estimate will be provided in the next slides

Summary of Cost Estimate

- FY16 (not including collaboration support of QA)

FY16	Existing Schedule			Accelerated Schedule	
	Effort	Cost		Effort	Cost
ASIC Development	0.5 EE			0.5 EE + 2 GS	
Board Development	1 EE			1 EE	
Labor		\$ 350,000			\$ 450,000
System Integration	2.5 EE/PD			2.5 EE/PD	
Labor		\$ 280,000			\$ 280,000
ASIC Submission					
M&S		\$ 120,000			\$ 240,000
CAD Tool					
M&S		\$ -			\$ 100,000
Total		\$ 750,000			\$1,070,000

FY16 Fund Summary	
SBND Fund @ BNL	\$ 350,000
SBND ASIC Dev Fund	\$ 250,000
DUNE Cold Elec Fund	\$ 150,000
protoDUNE Production Fund	\$ 640,000
Total	\$1,390,000

- Can we re-purpose the SBND fund arrived at BNL?
- Can we re-purpose the DUNE fund?
 - The impact on other developments (cold cable, feed-through etc.) will have to be examined

Summary of Cost Estimate

- FY17(not including collaboration support of QA)

FY17	Existing Schedule		Accelerate Schedule	
	Effort	Cost	Effort	Cost
ASIC Development	0.5 EE		0.5 EE + 2 GS	
Board Development	1 EE		1 EE	
Labor		\$ 350,000		\$ 450,000
System Integration	2.5 EE/PD		2.5 EE/PD	
Labor		\$ 280,000		\$ 280,000
ASIC Submission				
M&S		\$ 120,000		\$ -
CAD Tool				
M&S		\$ -		\$ 100,000
ASIC Production				
M&S		\$ 300,000		\$ 300,000
Total		\$1,050,000		\$1,130,000

FY17 Fund Summary	
SBND Fund	\$ 350,000
SBND ASIC Dev Fund	\$ -
DUNE Cold Elec Fund	\$ 250,000
protoDUNE Production Fund	\$ 280,000
Total	\$ 880,000

- DUNE cost and schedule will have to be examined for protoDUNE production and other developments for FY17 & beyond